Hardy Fern Foundation NEWSLETTER

Editor Sue Olsen ■ VOLUME 5 NUMBER 1 ■ WINTER 1995

President's Message

Sylvia Duryee

Winter doldrums?

This is a tough time for most gardens - except to look ahead. For many there is still deep cold and snow and ferns outdoors are quietly biding their time. However, it is a good time to start anew. Take a look at our spore list and choose something new you want to try in your area. Your window sill works well and this approach avoids the fern dislikes: sun, wind, cold. Best of all you can watch the exciting stages of growth up close.

Progress with our 1/3 of the new greenhouse at our Primary Display Garden at the Rhododendron Species Botanical Garden is exciting! Because of Tom Gillies generous gift, we are able to finance Steve Hootman's work in our behalf. We will soon have room to grow on small starts. The resulting material will be available to satellites, members, and for sale at the RSBG, also at our 25th Fern Festival in June.

Willanna Bradner has worked up a marvelous plan and layout for our display at the N. W. Flower Show, February 22-26th, the third floor of the Convention Center in Seattle. Be sure to visit, and if you are able to help call Janet Dalby at (206) 454-3447.

John van den Meerendook is putting together the elements for a 1 X 2 meter poster which will go to the Pteridological Symposium *(Pteridophyte's 95)* at Kew next summer, thanks to the strong arms of Sue and Harry Olsen. This gives us a full spring. Let us know what you are doing.

Thank you all /SCD

Shenandoah Fern Update

Joan Elger Gottlieb

Unlike printed words, ferns do not stay put. On recent trips to Shenandoah National Park in Virginia some changes in species distribution were noted and a couple of additional hybrids were found. This report updates the article "Shenandoah Ferns" in the Fall, 1993 H.F.F. Newsletter.

Woodsia obtusa can no longer be seen along the Skyline Drive at Fishers Gap (Mile Post 49.4,) a fire having apparently destroyed the colony. However, with a little footwork on the Lewis Falls Trail (diverges from the Appalachian Trail [AT] near Big Meadows Lodge,) it can be found on rocks about 0.2 mile before reaching the falls overlook. Also there are *Woodsia ilvensis*, *Asplenium trichomanes*, *A. platyneuron* and a *Cystopteris* species. *Woodsia obtusa* is also present on large rock outcrops along the Laurel Prong Trail near its junction with the AT about two miles east of Milam Gap (M.P. 52.8.)

Dryopteris x *triploidea* is fairly common along the Hogcamp Branch Trail below Dark Hollow Falls (M.P. 50.7.) Along with it are its two parents, *D. carthusiana* and *D. intermedia*, as well as nice populations of *Huperzia lucidula*, *Polypodium virginianum*, *Athyrium filix-femina* and *A. thelypteroides*.

Contents...............

Another hybrid, *Diphasiastrum* x *habereri* *(Lycopodium* x *habereri,)* is spreading in a sandy, acidic heath along the AT at M.P. 56.8. There is access to the trail from the Slaughter Fire Road here. Heading north, in about 100 yards the *D. digitatum* parent appears on the right, its long rhizomes growing out toward the trail. About 50 yards farther, the spidery-looking *D.* x *habereri* appears. Its rhizomes are mostly buried - visible only in a few spots where they surface briefly. A small colony of the D. *tristachyum* parent also grew in this area as recently as 1992, but I was unable to find it this year.

Changes in the fern flora reflect, in part, alterations in the park from the impact of weather and fire cycles, natural succession and overpopulating deer. A record of these changes will be continued.

Cyrtomium fortunei

Fortune's Holly Fern
Sir to'mium fortu'ne i
Cyrtomium = sickle shaped

James Horrocks, Salt Lake City

Of all the Cyrtomiums or holly ferns, this species is certainly the hardiest, surviving very cold winters where the mercury plunges well below zero. It is native to Japan, Korea, China, and Indochina.. It is found growing mostly in thickets in hills and low mountains. It usually produces fronds 12 to 18 inches long, although they may occasionally be longer. It is similar in many respects to the more familiar *C. falcatum,* which it is often confused with, but the fronds of *C. fortunei* are narrower, more erect, and not quite as shiny, tending to be more of a dark, greyish-green. Also, the pinnae are a bit longer, narrower, and of a thinner texture than in *C. falcatum.* It might also be confused with other *Cyrtomiums,* especially *C. tukusicola.* There are several varieties of *C. fortunei:* var. *clivicola,* var. *intermedium,* and var. *atropunctatum.*

Description: The rhizome is compact and more or less erect. The stipes are tufted, 5 to 10 inches long, densely scaly throughout, especially at the base, the scales being large, firm, and dark brown. The once-pinnate blade is broadly lanceolate and from 12 to 24 inches long by 4 to 6 inches wide. The simple lateral pinnae are numerous and alternating, 2 to 3 inches long and approximately one inch wide. They are chartaceous, and broadly lanceolate to narrowly ovate-oblong and usually auriculate on the anterior side although less pronounced than in other species such as *C. vittatum* and *C. balansae.* The pinnae are often minutely toothed and exhibit a dark, almost black costa or midrib, from which the veins form a network toward the edge. The apex of the frond is a single terminal pinna similar to the lateral ones. The sori are small, round, numerous and scattered. The peltate indusia are orbicular and subentire, often falling from older sori.

Photo by: Kim N. Durrant, SLC, Utah

Culture: This fern is at its best in shade in humus-rich soil. It seems to do equally well in either slightly acid soil or slightly alkaline. It is much more striking grown as a group or colony rather than individually. It may be grown in the open ground, but seems more at home nestled among large rocks. It makes a good pot plant, doing well indoors, but is more valuable outside in the shaded garden where its contrasting foliage compliments other ferns. It is really quite cold-hardy and is by far the more dependable of the *Cyrtomiums.* It is quite easy to grow and certainly has a place in any northern garden.

References:

Flora of Japan (1965) Jisaburo Ohwi, Smithsonian Institution, Washington, D.C.

Ferns of Hong Kong (1978) Harry H. Edie, Libra Press LTD, Hong Kong

Encyclopaedia of Ferns, (1987) David L. Jones, Timber Press, Portland

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Hardy Fern Foundation

Hardy Fern Foundation

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Articles, photos, fern and gardening questions, letters to the editor, and other contributions are welcomed!

Please send your submissions to Sue Olsen, 2003 128th Ave SE, Bellevue, WA, 98005.

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Hybrid Hi-Jinks

Joan Eiger Gottlieb

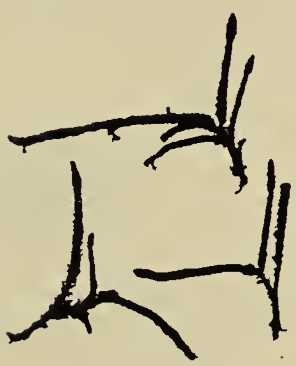
My awareness of hybridization in ferns and their allies dates back to undergraduate days at The City College of New York where I was doing a comparative study of plant vascular systems for a senior honors project in 1954. One day my mentor, Professor Joseph J. Copeland, brought in specimens of *Lycopodiella appressa*, *L. alopecuroides* and an "in-between" looking plant he had found all growing together in a sandy shrub bog near Lakehurst, New Jersey. A morphological study strongly suggested that the strange little lycopod was a hybrid, the first to be described for the *Lycopodium* group. I named the plant *Lycopodium* (now *Lycopodiella*) *x copelandii* in honor of the sharp-eyed botanist who found it, and it was the subject of my first published paper (Eiger, 1956.) Montgomery and Fairbrothers (1992) report that a whole array of bog lycopod hybrids occurs along the coastal plain where parental populations overlap.

Hybrid fern allies are now well documented in the literature, with new ones still being discovered and described in nearly all genera. In addition to several bog *Lycopodiella* mixed crosses, I have personally seen the hybrids of *Huperzia lucidula* with both *H. selago* and *H. appalachiana*, and of *Diphasiastrum (Lycopodium) digitatum with D. tristachyum (= D. x habereri.)* I had the special good fortune to learn about these hybrids with the late Joe Beitel of the New York Botanical Garden, for whom this group of fern allies was a particular passion.

Hybrid ferns have appeared in herbaria for over a century. It was in 1866 that Berkeley recognized x*Asplenosorus ebenoides* as the hybrid between *Asplenium platyneuron* and *Camptosorus rhizophyllus.*

In 1940 Tryon described *Osmunda* x *ruggi*, a spectacular scion of *O. claytoniana* and *O. regalis.* Many more discoveries followed so that today there are dozens of known hybrid ferns.

Lycopodiella appressa (Lloyd & Underw.) Cranfill
Appressed Bog "Clubmoss"
Rhizome completely prostrate, hugging the substrate and rooting throughout its length.
Leaves on erect stems appressed to stem, lack teeth.



Lycopodiella x *copelandii* (Eiger) Cranfill
Hybrid bog "Clubmoss"
Rhizome part prostrate and part arching, rooting at end and occasionally along middle.
Leaves on erect stems partly spreading, one or two pairs of teeth.

Lycopodiella alopecuroides (L.) Cranfill
Foxtail "Clubmoss"
Rhizome arches over substrate, rooting at end.
Leaves on erect stems spread outward, toothed.

Figure 1

WHAT IS A SPECIES?

The biology of hybridization, with its implications for gene, cell and evolution theories, not to mention horticulture, has always held a certain fascination for me. The introductory hype and nostalgia notwithstanding, hybrids are NOT supposed to happen in nature. The eminent ornithologist and systematist Ernst Mayr (1964) says that a biological species is a "group of actually or potentially interbreeding natural populations, which are reproductively isolated from other such groups." Each species is thus a contained gene pool - a group that does not exchange or intermingle its genes with the genes of other groups, and, therefore, evolves in its own unique direction. There can be variation within the group (the familiar bell-shaped curve for most traits,) but none that affects the reproductive compatibility of its members.

If a mutation (heritable change) occurs that prevents reproduction between members of such interbreeding populations, it can be an isolating factor, and may establish a path to new speciation even if the affected individuals resemble each other superficially for a time. Such reproductively separate, but similar-looking cryptic or sibling species have been described in animals (e.g. *Drosophila persimilis* and *D. pseudoobscura*) and in ferns (*Botrychiium hesperium* and *B. echo.*) For insects, a slightly different pheromone, and for birds, a variation in the nuptial dance may suffice as reproductive barriers. Plants may have different blooming schedules, pollen-stigma compatibilities or specific sex cell membrane receptors that set populations inexorably onto separate evolutionary paths, even if their appearance remains remarkably similar and their geographic ranges coincide.

More typically there are habitat preferences (meadow versus forest) or geological barriers (the elevation differences of mountain ranges, the separation of land masses as islands or continents, the physical distances across large canyons, rivers and lakes) enabling organisms once clearly related to evolve in isolation long

continued on page 4

enough to achieve genetic uniqueness, reproductive separateness and even morphological distinctiveness - i.e. typical species identity.

So, if even small differences can set species apart reproductively, how can we explain those embarrassing hybrids that arise from inter-species promiscuity often enough to blur our best species definitions? The answer, as E.O. Wilson (1992) so poetically put it, is that "real evolution is messy." One or more of the isolating mechanisms may not be 100% effective - there are few absolutes in biology - particularly in species recently derived from a common ancestor and still sharing a lot of traits crucial to reproduction and survival. Most traits that arise through mutation undergo natural selection for their adaptational value, not for their isolating potential, the latter coming about secondarily in some cases.

Ecological disturbance, climatic cycles and other "natural history" factors may bring evolving species (subspecies) back into overlapping proximity, in the biochemical or developmental senses, as well as the more obvious geographical one. For example, changing moisture patterns may bring fern gamteophytes (sexual plants) of different species into reproductive maturity at the same time, allowing fertilization of one species' eggs by the other's sperm. Under more stable environmental conditions each species might reach reproductive maturity at different, non-overlapping points in the season. On field trips I have observed that the "super sites" for finding hybrids of *Dryopteris* are almost always hardwood swamps and their borders, places with fluctuating water levels and a diversity of potential parental species, particularly those reaching their southern and/or northern distribution limits - transition zones, so to speak.

THE SIGNIFICANCE AND EXTENT OF HYBRIDIZATION

According to Barrington et al. (1989,) hybrids are common among ferns. Indeed, Montgomery (1992) lists 32 hybrids in 5 genera of ferns and fern allies for the state of New Jersey alone. This represents 25% of the stateÆs pteridophyte taxa, although most of the hybrids are rare. Hybrid ferns are often larger than their parents, having "hybrid vigor." They are popular as specimen plants for outdoor shade gardens.

There has been past controversy about the relative importance of natural hybridization in evolution. Lotsy (1916) thought it was the "single most important factor" in producing genetic variation and Wagner (1970) dubbed it no more than "inconsequential evolutionary noise." Since then it has been realized that something between these extremes may be closer to the truth. It has been estimated (Arnold, 1994) that 70% of flowering plants owe their existence to past, natural hybridization and introgression (backcrossing of hybrids to one or another of its parents.) Modern DNA analysis confirms that hybrids have contributed genetic material to the genomes of many different taxa.

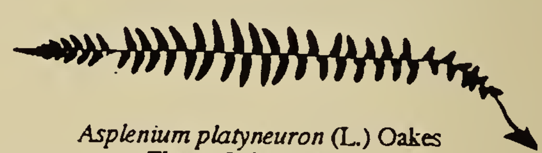
It would appear, at the very least, that natural hybridization can make a creative contribution to adaptation and speciation. We can agree with Barrington that:

1) Hybrids represent secondary contact (renewed reproductive interaction) between populations or species following a period of isolation.
2) Hybrids arise where isolating mechanisms fail or are incomplete and there is a break in the process of divergence.
3) Hybrids are a "rehash" of traits that are already present as well as a novel recombination of these traits - a new "shuffling" of the genetic deck.
4) Only if two taxa hybridize freely and amalgamate into one polymorphic evolutionary lineage is species diversity reduced rather than enhanced.

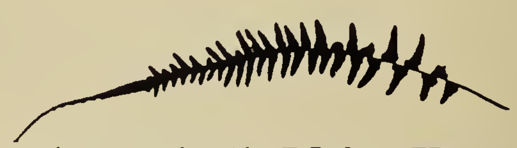
NOMENCLATURAL NOTES

If a hybrid is fertile it is treated as a full-fledged new species - a hybrid or nothospecies (as opposed to an orthospecies, the more traditional type that arises through mutation, isolation, natural selection and divergence within populations.) Such a fertile hybrid species is given a name of its own, e.g. *Dryopteris celsa*, *D. carthusiana*, *Cystopteris tennesseensis*, et al.

If the hybrid is sterile both parents are usually specified, e.g. *Dryopteris carthusiana* x *intermedia*. Sometimes, a sterile hybrid is given a name or epithet of its own. The *Dryopteris* hybrid above is often referred to as *D.* x *triploidea*, the "x" alerting the reader to the plant's hybrid nature. Often, the epithet honors a botanist associated with the hybrid, e.g. *Dryopteris* x *neo-wherryi (D. goldiana* x *marginalis)* or the *Lycopodiella x copelandii* cited at the start of this essay.



Asplenium platyneuron (L.) Oakes
Ebony Spleenwort



x*Asplenosorus ebenoides* (R.R. Scott) Wherry
(*Asplenium platyneuron* x *Camptosorus rhizophyllus*)
Scott's Spleenwort

Camptosorus rhizophyllus (L.) Link
Walking Fern

Figure 2

Intergeneric hybrids are also known and named. Scott's Spleenwort, the well-known blend of *Asplenium platyneuron* and *Camptosorus rhizophyllus* is designated as x*Asplenosorus ebenoides* with the "x" in front of the new generic designation. Similarly, there is

x*Aglaonaria robertsii* - the intergeneric blend of *Aglaomorpha coronans* x *Drynaria rigidula*. And how about a trigeneric hybrid - *Asplenosorus pinnatifidus* (a fertile hybrid of *Asplenium montanum* and *Camptosorus rhizophyllus*) x *Phyllitis scolopendrium* var. *americana*. This was actually created by chance in a terrarium in Michigan in 1965. Hoshizaki (1993) recommends that hybrids created in cultivation be given a cultivar designation in addition to the species epithet, e.g. x*Aglaonaria robertsii* cv. Santa Rosa for a variant of this hybrid produced by a California grower. Such hybrids reflect the close relationship of the genera involved. Indeed, some taxonomists recommend "lumping" *Camptosorus* and *Phyllitis* with *Asplenium*.

Asplenium montanum Willd.
Mountain Spleenwort

x*Asplenosorus pinnatifidus* (Nutt.) Mickel
(*Asplenium montanum* x *Camptosorus rhizophyllus*)
Lobed Spleenwort

Camptosorus rhizophyllus (L.) Link
Walking Fern

Figure 3

The "typical" homosporous pteridophyte life cycle, based on *Camptosorus rhizophyllus*, the "Walking Fern" and showing the alternation of a small, free-living, haploid gametophyte and a large, long-lived, diploid sporophyte with true roots, stems and leaves.

HOW HYBRIDS HAPPEN

Horticulturists and plant breeders, armed with camel's hair brushes and "baggies" of assorted shapes and sizes, have mastered the art of artificially intermarrying different species to bring us countless new hybrid flowers, fruits and veggies. The modern tomato is a marvelous mix of at least nine different species from Central and South America, carefully interbred over countless generations to incorporate into one plant such desired traits as temperature and drought tolerance, disease and pest resistance, color intensity and increased vitamin and sugar content. Today, such traditional, time-consuming selective breeding is being superseded by genetic engineering techniques of direct gene transfer - chemically cutting desired genes from the chromosomes of one species and using harmless viral or other vectors to splice them into the chromosomes of another species. Hybridization between entire genomes and painstaking selection of the "superior" offspring has been bypassed. Sex has been subverted, indeed, eliminated from the process!

Natural hybridization is still dependent upon chance sexual unions between different taxa. For angiosperms (flowering plants) this means pollen tube growth on the pistils (seed making parts) of flowers and subsequent fertilization of the egg nucleus at the base of the pistil by the sperm nucleus produced in the pollen tube. To have a sexual union happen inside a flower, blooming time, structural differences and even chemical barriers must be overcome by the pollen of one species trying to grow on and interact with the pistillate structures of another. Intra-specific pollen competition is often the first and greatest barrier of all (another way of saying that each species "prefers" and makes it easiest for its own pollen.) Thus, first generation hybrids are very rare - Arnold (1994) estimates less than 1% between two *Iris* species which grow and bloom together in southern Louisiana. However, participation of these rare hybrids in subsequent generations is quite high, with backcrosses to one or the other parents (introgression) common, resulting in great diversity within certain populations.

The pollen tube and egg-making part of the flowering plant pistil are homologous (related in development and evolution) to the thalloid gametophytes of ferns and their allies. In pteridophytes natural hybridization can occur only if the fragile, haploid (one set of chromosomes) gametophytes of two different taxa grow on or in the same moist substrate, near enough to each other for the sperms of one to swim toward and fertilize the eggs of the other. Ecology, phenology (seasonal factors) and chemistry typically conspire against such illicit

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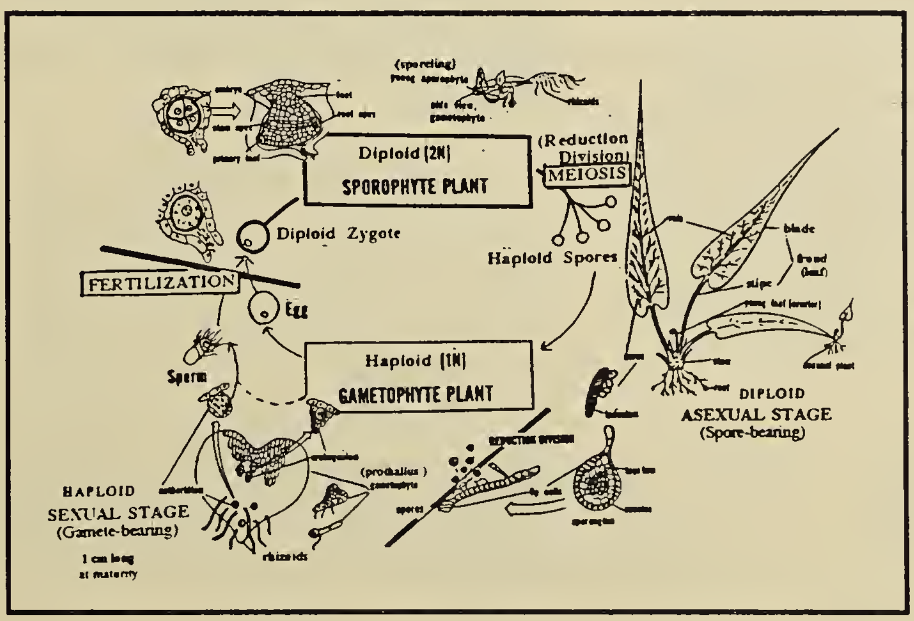


Figure 4

unions, but occasionally sex between species or even genera is successful and a hybrid fertilized egg (zygote) is formed. This zygote develops into a diploid (two sets of chromosomes) sporophyte (the familiar, long-lived fern or "firmoss" with true roots, stems and spore-bearing leaves.) However, the species concept generally is not invalidated by all this because most pteridophyte hybrids are sterile.* The reason for this sterility is that structural differences in the chromosomes from their parental taxa generally prevent proper pairing during meiosis - the special reduction division process that precedes spore formation. The set of chromosomes "A" from one parent simply cannot find homologous matches (chromosomes with genes for the same traits) among set "B" from the other parent. It still takes "two to tango." The result is spores and even sporangia that are "abortive" - shrunken. misshapen and lacking contents. Some hybrids produce a small percentage of viable spores, a few cells apparently having enough matched chromosomes to complete meiosis successfully.

If, however, the hybrid undergoes a spontaneous doubling of its chromosomes right before spore formation, the resulting "allopolyploid" cell(s) can have normal meiosis. Now the matched, duplicated chromosome partners are able to line up at the cell equator to be apportioned to the daughter cells that will differentiate into sproutable spores. And these polyploids can often cross back to their parents or with other species to create still more taxa. "Reticulate evolution" as Wagner (1954) calls this process has created polyploid, interbreeding complexes in several genera, including *Asplenium*, *Dryopteris*, *Polystichum* and *Isoetes*.

Species "a" — X — Species "b"
1N = 11 (A) — 1N = 11 (B)
Isoetes echinospora — *Isoetes engelmanii*

↓

Sterile Diploid Hybrid "a" x "b"
2N = 22 (AB)
Isoetes x *eatonii*

↓ spontaneous chromosome doubling

Fertile Tetraploid Hybrid 2("a" x "b")
4N = 44 (AABB)
Isoetes riparia

All plants share an unusual "jekyll-and-hyde" life cycle with an alternation of sexual (gamete-bearing) and asexual (spore-bearing) plants, the gametophyte and sporophyte, respectively. In the pteridophyte group both generations are independent, free-living and visible (although the tiny haploid gametophytes may be prayer-bones finds.) In the seed plants (and a few heterosporous fern allies) only the diploid sporophyte lives free, the gametophytes being reduced to a few cells or nuclei imprisoned within the tissues of the spore-bearing leaves (cones and flowers) that produce them.

*Some hybrids, e.g. *Huperzia appalachiana* x *lucidula* and x*Asplenosorus ebenoides* can reproduce vegetatively by gemmae or foliar buds, allowing even rare hybridization events to multiply into many, clonal individuals, some persisting for long periods of time and even out-surviving parental populations in an area.

Hybridization, when it occurs, belongs to the gametophyte generation, those tiny, but sexy plants so often overlooked on soil (most ferns,) in water (*Marsilea*, *Isoetes*,) underground in association with fungi (*Lycopodium*) or in the axils of fertile leaves where the large spores destined to grow into female gametophytes remain attached (Selaginella.)

A bizarre complication in hybrid formation may come about through apogamy, or agamospory as it is now called (Gastony and Windham, 1989.) Unreduced spores (2N) grow into diploid gametophytes which then produce diploid sporophytes directly (without fertilization.) Ten percent of fern species are known to reproduce in this inbred way, at least in some populations. These include some species of *Pellaea*, *Cheilanthes* and *Notholaena*, perhaps as an adaptation to xerophytic (dry) habitats where water-dependent fertilization is not reliable. To complicate matters further, these ferns can produce diploid sperm that act as male parents in crosses with sexually reproducing individuals. The hybrids of such crosses include populations of triploid *Pellaea atropurpurea*, *Cystopteris protrusa* and *Notholaena grayi*. Triploid sperms from such plants can then fertilize haploid eggs of sexually "normal" neighbors to produce tetraploids! Tetraploids can also be produced by doubling the chromosomes of diploid agamosporous plants. Hexaploids (6N) and even higher ploidal levels are known from such bizarre behaviors. All of this chromosomal confusion can be found in the *Pellaea glabella* complex. The only way to distinguish these unusual populations is through enzyme and/or chromosome analysis.

E.O. Wilson (1992) estimates that polyploidy has been responsible for the origin of nearly 50% of extant angiosperms and a small number of animal species. According to Montgomery (1992,) six of the thirteen fertile North American

Dryopteris species are polyploids - almost exactly coincident with Wilson's estimates for higher plants. A few examples may be of interest here. We can define polyploids as plants having high multiples of the base (haploid) number of chromosomes associated with its kind. The base number for the genus *Dryopteris* is 41. *Dryopteris clintoniana* is a hexaploid, having 246 chromosomes in its body cells. *Dryopteris celsa, D. cristata* and *D. carthusiana* are tetraploids with 164 chromosomes each. Many polyploids have arisen from past hybridizations followed by chromosome doubling, as has already been described. *D. celsa is* believed to be the fertile allopolyploid hybrid of *D. goldiana* and *D. ludoviciana. D. carthusiana* has, as one of its parents, *D. intermedia*. Its other parent is not known. *D. cristata* is the hybrid between this same undetermined parent and *D. ludoviciana*. All of this suggests that the genus *Dryopteris* is of fairly recent evolutionary vintage, with many of its diverging species still compatible enough to reunite under favorable conditions.

HOW TO HUNT FOR A HYBRID

A hybrid hunter in the field can use the following recipe for finding and recognizing hybrid ferns and their allies.

1) Search for the occasional "odd-looking" specimen in a field of two or more related species. (The whole plant must look unusual, not just one or two fronds. Often, ferns will produce a few atypical leaves, especially late in the growing season.) A hybrid is often larger and more vigorous-looking than any surrounding parent plant..

2) Check to see if the unusual plant has any characters of two different species blended together, e.g. *Dryopteris marginalis* has marginal sori; *D. goldiana* has sori along its central pinnule veins; *D.* x *neo-wherryi*, the hybrid between them, has sori almost exactly half way between margin and vein. *D. intermedia* has more or less equal-sized pinna pairs and lots of glistening little glands shaped like lilliputian nails, particularly on the rachis of the leaf. *D. carthusiana* is glandless and has very unequal pinna pairs, particularly near the base of the frond. *D.* x *triploidea*, their rather common hybrid, has glands (like *D. intermedia*) and unequal pinna pairs (like *D. carthusiana*.) The earliest realization that plants hybridize was based on observation of such morphological intermed-iacies or new arrangements of parental traits. See F. and L. Thorne (1989) for many, good illustrations of hybrid trait combinations.

Dryopteris marginalis (L.) A.Gray
Marginal Wood-Fern
pinna showing sori along margins

Dryopteris x *neo-wherryi* W.H. Wagner
(*Dryopteris goldiana* x *marginalis*)
pinna showing sori half-way between margin and midvein

Dryopteris goldiana (Hooker) A. Gray
Goldie's Wood-Fern
pinna showing sori along midvein

Figure 5

Dryopteris carthusiana (Vill.) H.P. Fuchs
Spinulose Wood-Fern (4N =164)
basal pinna showing unequal pinnule pairs: lacking stalked glands: deciduous

Dryopteris x *triploidea* Wherry (3N = 126)
(*Dryopteris carthusiana* x *intermedia*)
pinnae resemble *D. carthusiana*, but glandular like *D. intermedia* and sub-evergreen

Dryopteris intermedia (Muhl.) Gray
Evergreen Wood-Fern (2N = 82)
basal pinna showing equal pinnule pairs: stalked glands on rachis et al.: evergreen

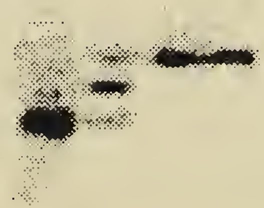
Figure 6

3) Look for large numbers of undehisced (unopened) sporangia on old fronds. These can be seen with a hand lens and may indicate a hybrid. Collect a fertile pinna or two and check under a microscope (at about 40x) for aborted sporangia and spores (irregular, non-uniform shapes, shrunken appearance, pale color and solid-looking, empty interiors.) One caveat is notable here; spore abortion is also common at times for normal plants growing in high-stress environments, such as alpine conditions, e.g. *Diphasiastrum (Lycopodium) alpinum, D. sitchense* and *D. complanatum*.

4) In the laboratory more definitive analysis of hybrid status includes squash preparations of young sporangia to look for unpaired meiotic

continued on page 8

Gel electrophoresis "zymogram" for PGI (phosphoglucoisomerase) showing the "a" and "c" allozymes of this enzyme from *Polystichum lemmonii* (L) and *P. munitum* (M) and the combined allozymes for this same enzyme in their hybrid (H.) From Soltis et al. 1989.



a

c

M H L L

Figure 7

chromosomes. For refractory cases, paper chromatography and gel electrophoresis are "state-of-the-art" tests by which scientists can verify the presence of species-specific flavonoids* and enzymes from both putative parents. Using allozyme** gel electrophoresis, Haufler (1985) discovered that *Cystopteris tenuis* and *C. fragilis* share a common, unknown, diploid ancestor. In the same way, Hickey et al. (1989) showed that three named *Isoetes* species from different Costa Rican lakes were, in fact, a single species exhibiting clinal (elevation) variation due to temperature and isolation. Soltis (1989) analyzed nine enzymes to demonstrate that interspecies hybridization is rampant among North American Polystichums. *Polystichum acrostich-oides* x *P. braunii* = *P.* x *potteri* in Vermont and *P. andersoni* crosses with *P. munitum* in Alaska. *P. munitum* is highly outcrossing, creating fairly good hybrid : non-hybrid population equilibria in the Pacific Northwest. Crawford and Giannasi (1982) have written an excellent explanation and review of these new "chemosystematic" techniques.

WHAT DOES IT ALL MEAN?

Hybrid formation is one way taxa "tell" us they are related. The most common hybrids are those that form between subspecies (those populations most recently separated or separating from each other, breaking the gene pool into geographically isolated puddles.) Hybrids between species are rarer, but occur with fair frequency between those species that are close to the fork of the evolutionary branch that separates them, rather than those that are out on the ends of its limbs. Generic hybrids are rarer still and hybrids between members of higher taxa are truly needles in the biological haystack. But, all of these hybrids remind us that related organisms share more common DNA than that which distinguishes them. If isolating mechanisms break down, some of these DNA pools find that they can still flow together. And, with the vast ecological change being wrought in modern times, we may find more border or friction zones created where previously isolated species or "species-in-the-making" are brought back together. Their gametes may thus have renewed opportunities to test their compatibility. Those that "make it" will produce hybrids to bemuse and confuse us.

*Flavonoids are C_6-C_3-C_6 compounds often occurring as glycosides (carbohydrates combining a sugar such as glucose with a non-sugar such as digitalin, anthocyanidin, etc.) and including many of the most common pigments of flowers and pollen.

**Allozymes are similar, but not identical, enzymes coded by alternative alleles (from mutation) of the same gene (like different flavors of the same ice cream.) Hybrids display "additive" allozyme patterns when separated electrically in a gel, the pattern of one parental species "superposed" upon that of the other.

If all this has seemed confounding and complicated, it is worth noting that taxonomy is a human construct - a tool created by and for the convenience of taxonomists. Plants "feel" no obligation to fit into neat, nomenclatural nooks. They pursue their own proclivities, sexual and asexual, within their own "species" and sometimes with other species, just for a change. Life is a continuum, with indistinct boundaries and with lots of life forms that do not fit neatly on one or the other side of those boundaries. For pteridophytes, the continuum extends nearly 400,000 years back to the Devonian, enough time for a lot of evolutionary experiments, the successful ones comprising about 13,000 species in our modern flora. Since my college days these ancient plants have had a special place in my affection. The fact that there is a certain "messiness" to their classification is not troubling; it is, instead, an indicator of their versatility and enhances their mystique. Hybrids are a further reflection of their dynamic nature and the fullness of their potential.

Hybrids also heighten my desire to preserve and protect our remarkable flora and the habitats that sustain it. That way, future generations will also be able to hunt for hybrids and speculate about their origin and their evolutionary significance.

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To Our Fern Growers:

Wayne "Bubba" Baxter

I would like to explain my Spore Exchange policy. I feel it will make for a better exchange in the long run if everyone knows how I am operating.

First of all I am constantly looking for input, new ideas, complaints, etc. Please feel free to express your concerns at any time. Below are some of the policies that I have for operating the Exchange.

Requests are handled on a first come first serve basis. Except in two situations donors always have priority over nondonors. In the event of a tie between overseas and domestic donors, the overseas donor gets priority to help keep them donating their diverse spores.

I always use the freshest spore that I have available, unless there is a specific request for Donor or Coll. site.

When it comes to the packets of spores if I have a lot I give a lot, if I have a little I give a little. When I have a small donation I try to make it stretch to as many members as I can and still have enough to grow. There are some donations that have almost no spore at all. Rather than just throwing it out I will try to package it and send it out in the hope that the member will, at least, have a <u>chance</u> of growing it. The short ones will be reflected in the Spore List each year, although some of the short ones aren't designated in this year's list as I just started this idea. Also the individual packets on the short ones will have a circle with a minus sign inside. If you get one of these that was not listed in the Fern List, it will be because I <u>had</u> full ones but have since run out of full packets. I <u>try</u> to make sure that there are always <u>some</u> spores in each packet.

But please understand I am <u>not</u> holding back any spores - I give what I am given. The quality and quantity of the <u>donations</u>, are reflected in what you receive. I am doing this exchange without any assistance so if I get a donation that has debris I do not have time to separate <u>all</u> of it from the spores.

Though there are still some old packets left all new packets will have, in the lower left hand corner, their collection site if they were collected in the wild. The lower right hand corner will have the initials of the donor and the year the spore was donated.

This year when I am out of a fern that you order you can either ask for a substitute at that time, or get a voucher that can be used for a future order.

My goal in taking the Exchange is to make it the preeminent source of ferns in the world. I can only succeed with your help. Only 40 people donated last year, and almost half were from overseas. I think that there are a lot more of us out there who could be sending spores in. They don't have to be exotic or rare: any identified spore is helpful. Send in all of the local ones that you have no matter how mundane you think they are. When you travel grab a couple of fronds and (after identifying them) send their spores in — with relevant information noted on the donation.

Remember the better the condition of the donations the better the spores that you receive.

Thank you for your cooperation!

To My Fellow Fern Collectors:

Wayne "Bubba" Baxter

I am looking for members who live near Botanical Gardens. My goal is to find members who will go to these Gardens and collect fern spores for the spore exchange. I will make all of the arrangements with the appropriate authorities.

It will need to be done at least once a year, maybe more. That would be up to you considering the needs of the exchange. This idea, if I get a good response, can add a lot of rare and unusual ferns to the exchange. You would be recognized in the annual spore exchange for your work. I will refer to you in correspondence with the Botanical Gardens as the HFF spore curator for (your state).

I have done this myself with the Nat. Botanical Gardens in D.C. and have found it an interesting experience. The curators are very helpful and supportive.

Anyone interested in participating please let me know. I will need the address of the Bot. Gard that is near your location.

Thank you for your consideration!

Fern Growing Idea

Wayne "Bubba" Baxter

This is a method that I have used to raise ferns from spore. It works so well for me that I want to pass it on to other members. I utilize the containers that are used for cakes and cupcakes at the supermarket. They are clear plastic. They hold the humidity well and let in plenty of light. The cupcake container will hold 6 ferns. Another plus is that they are stackable. I have piled them 5 high without any mishaps. You can grow a lot of ferns in a very small area near a window. Plus they are free, one container with each purchase of cupcakes. The ferns love these little greenhouses.

The 1995 HFF Spore Exchange Addendum

As you can see the Spore Exchange Addendum is coming out earlier this year. A description of the columns is listed below.

COMMON NAME : No explanation necessary here.

PACKET: How many packets we have in stock at the time the list was published. This should key possible donors. If you see one that is running low, that you have, please send it in.

ZONE: The zone listed is the most northern zone the fern has been reported to grow in. If I had no information on where the fern grows I put zone 9.

SIZE:, this is the largest size that the fern can be expected to grow under ideal conditions. Ordinarily your fern will be smaller.

GROwing conditions: There is a different letter for each condition listed that the fern prefers for optimum growth.
A=ALKALINE SOIL, Z=ACID SOIL, S=SHADE, T=PART SUN, U=UNLIMITED SUN, D=DRY SOIL, N=NORMAL DAMPNESS, W=WET, H=HIGH HUMIDITY, E=EASY TO GROW, Q=DIFFICULT, L=SOIL SPECIFIC, R=ROCKY SOIL, J=EPIPHYTIC, B=TREE FERN C=CLIMBER, G=SPREADING HABITS, K=TERRESTRIAL, Y=DIMORPHIC, V=DECIDUOUS, O=EVRGREEN

COLLECTION site is where the spore donation was collected if it was collected in the wild. When ordering spores from the wild you must spell out the site that you would like them to come from, otherwise you will receive whatever packet of spore is on top at that time.

ORIGIN this is the natural range of the fern.

DONOR column lists the donors of the various spores. It is listed with the year the spore was donated beginning with the most recent; then the donor number. There will be a space between successive years. If you want spore from a specific donor you must specify whose you want.

There are also numbers listed in with the genus that impart the following information. 1=RARE, 2=NEW never listed before, 3=FEW spores in the donation, maybe too few to grow, 4=BOTANICAL GARDEN DONATION, 5=FOR MY DATA USE ONLY, \$=GREEN SPORES, \$\$\$ GREEN SPORES with a fresh spore donor available. We are by the way, still looking for more green spore donors. If you want to volunteer please make it known when you make your requests or donations.

The information in the list should be taken as advisory in nature only, not as proven fact. If any member has any reliable information that should be added to, or changed in, the list please forward that information with your spore donation or request.

Below the spore list are the donors and their respective donor numbers from 1991-1994. Some may have been lost during the transition of the exchange, I apologize in advance if anyone is overlooked. The ones with an asterisk deserve special recognition for turning in many different kinds of spores in very good condition.

It is urgently requested that donors send in fresh spore every year. The life of the Exchange depends on your contributions of spores collected from many different localities from around the world. If time allows please mark each donation with pertinent information regarding the fern, that the spore was collected from.

Much of the excellent information in this list, has been provided thanks to the efforts of two members Brian Aikens, and Robert Louis Muller. Additionally we need to thank our new curators who will be collecting spores from Botanical Gardens in their areas Judy Quattrochi, Betty Blake, Iris Gaddis, Jim Rugh, Owen Hammerberg. Judy has already sent several in from the NYBG. When you start to receive spore packets with the species printed out neatly, with zone, etc. you can thank Owen Hammerberg. He recently sent me thousands of labels at his own expense. Many members will be very thankful as my handwriting skills aren't always what they should be. I will begin sending them out as soon as I get some time to place them.

To Order: Please print your selections clearly in alphabetical order using Botanical name. Include 25 cents for each fern requested (check payable to the Hardy Fern Foundation) and a self-addressed stamped envelope. No charge for requests from overseas, but please enclose an International Postal Response Coupon to help with the return of the spores. Maximum order is 25 packets per year.

Mail Requests To:

Wayne D. Baxter
307 Riverdale Cir.
Stephenson Va., 22656, USA

HFF	GENUS	SPECIES	CVR	COM. NAME	PK	Z	SZE	GRO	COLL.SITE	ORIG	DONOR
344	Adiantum	capillus-venens	Reginae	venus hair fern	1	8	18	ASHK		pantrop	94/45 93/9
345	Asplenium	cuneifolium			6	6		R	Bohem,CzechSwtz	Eur	94/45
346	Asplenium	incisum			5	4	10	ZYK		NE Asia	94/45
347	Asplenium	scolopendnum		harts-tongue, scollies	13	6	12	ANSKO		NHem	94/150,152,97
348	Asplenium 1	septentrionale		forked spleenwort	70	5	10	ZDTK	Switz,Italy	NHem	94/9,45,152,154
349	Asplenium 1 2 3	x alternifolium			5	5		R	Germ	Eur	94/45
350	Asplenium 1 2 3	x lusaticum			5	5			Germ	Germ	94/45
351	Asplenium 1 2 3	x poscharskyanum			5	5			Germ	Germ	94/45
352	Asplenium 1 3	trichomanes	Pachyrachis	Maidenhair spleenwort	6	5	14	ANT		Czech	94/45
353	Asplenium 2	Scolopendrium	Supra marginatum	Harts Tongue fm	10	6	12	ANSKO		NHem	94/155
354	Asplenium 2 1	Trichomanes	Hastatum	Maidenhair spleenwort	5	5	14	ANT	Switz	Switz	94/45
355	Asplenium 2 3	x Murbeckii			1	6			Switz	Switz	94/45
356	Asplenium 3	ruta-murena	Dolomiticum	Wall rue	1	4	6	QANT		N Italy	94/45
357	Asplenium 3	trichomanes	Lucanum	Maidenhair spleenwort	5	5	14	ANT			92/45
358	Athyrium	filix-femina	Curtum cristata	lady fern	5	3	48	ZNTKOV		N HEM	94/45
359	Athyrium 2	Thelypteroides		Silvery Glade Fern, Silvery	1	4	36	TNZV	Me	NHemIndia	94/120
360	Athyrium 3	filix-femina	Corymbiferum	lady fern	6	3	48	ZNTKOV		N HEM	94/45
361	Athyrium 3	rubripes			1	6				Siberia	94/45 93/9
362	Athyrium 3	spinulosum			5	4	24	SNK		EAsia	94/45
363	Blechnum	minus			20	6	40	WTK	AukNz	Aus, NZ	94/37
364	Blechnum	spicant		ladder fern,	30	6	28	ZESWY	Wash	N Hem Pac nw	94/9 36,97,154
365	Ceterach 2 3	officinarum	bivalens	see asplen ceterach	3	5	6	ADT		India,Af,Eur	94/45
366	Ceterach 2 3	officinarum	officianarum	see asplen ceterach	2	5	6	ADT		India,Af,Eur	94/45
367	Cheilanthes 2 3	notholaena	marantae		5	6		DU	Cauc	Caucasia	94/45
368	Cyrtomium	caryotideum		Dwarf holly fern	10	6	12	ZNTK		India,Easia	94/156

369	Cystoptens	bulbifera		Bladder Fern	6	3	28	ANTVK		N A	94/97 93/9
370	Cystopteris	fragilis		Brittle Bladder fm, fragile fern	90	4	12	ZNTVK	Oreg Germ. eagle crk.	Cosmo	94/9,12,97,154
371	Cystoptens 2	fragilis	Fine Form	Brittle Bladder fm, fragile fern	90	4	12	ZNTVK	Germ. eagle crk.	Cosmo	94/24
372	Cystoptens 3	fragilis	anthriscifolia	Brittle Bladder fm, fragile fern	5	4	12	ZNT		Cosmo.	94/45
373	Davallia	canariensis		canary is. hares-foot fn	4	8	16	GDUMJ		Port,Spn,Cnry	94/152,154 93/9
374	Dryoptens	affinis	borren	scaly male fern. golden	20	4	48	SNK		Eur SWasia	94/135
375	Dryoptens	affinis	borren robusta	scaly male fern. golden	20	4	48	SNK		Eur SWasia	94/135
376	Dryoptens	affinis	Pinderi	scaly male fern \ golden	7	4	48	SNTK		Eur SWasia	94/150
377	Dryoptens	dilatata	Crispa Whiteside	crisped broad buckler fern	26	5	36	WTOSK		N Hem	94/25 92/113
378	Dryoptens	filix-mas	Cristata Martindale	Male Fern	20	3	60	ZSNV		N Hem	94/25
379	Dryoptens 2	affinis	Conacea	male fern	1	4	24	SNTK		Iran	94/45
380	Dryopteris 2	affinis	Punctata	male fern	5	4	24	SNTK	Switz	Switz	94/45
381	Dryoptens 2	Filix-mas	Lineans Plumosa		17	4	60	ZSNOK		N Hem	94/12,141
382	Dryoptens 2	filix-mas	sublineans polydactyla	Male fern	21	4	60	ZSNOK		N Hem	94/25
383	Dryoptens 2	sieboldii	Cvenata		5	6	10	ZSNK		Easia	92/111
384	Dryoptens 2	varia		see d. bissetiana	10	6	24	ZSNK		Sasia,Philipin	94/45
385	Dryoptens 2 3	Intermedia	Maderensis	Evergreen Wood Fern	1	3	24	ZSNOK		Madeira	94/45
386	Dryoptens 2 3	Namegatae			5	7				Jap	94/45
387	Dryoptens 3	filix-mas	Cristata Jackson	Male Fern	3	3	60	ZSNOK		N Hem	94/45
388	Dyopteris 2	Gymnosora			5	8	12			Japan	94/36
389	Gymnocarpium	dryopteris	Plumosa	plumose Oak Fern	20	4	12	RSGV		NHem	94/9,25
390	Lygodium 1	palmatum		American,Hartford fn	12	4	60	CWZTQ		E.NAm	94/8
391	Osmunda $$$	cinnamomea		Cinnamon Fern	1	3	60	WZVK		Cosmo	94/150 93/9
392	Osmunda $$$	claytoniana		Interrupted Fern	5	3	60	ZWSVK	Me	Cosmo	94/138,5,150
393	Osmunda $$$	regalis		royal fern	20	3	90	ZWSOK		Cosmo	94/154
394	Osmunda $$$	regalis	gracilis	royal fern	1	4	48	ZWSVK		N. Hem	94/5
395	Osmunda $$$	regalis	spectabilis		1	3	90	ZWSVK		Cosmo	93/9,150
396	Osmunda 2 $$$	regalis	Japonica(Dimorphic)	royal fern	1	4	48	ZWSVK		N. Hem	94/5
397	Osmunda 2 $$$	regalis	Undulatum	royal fern	1	4	48	ZWSVK		N. Hem	94/5
398	Phyllitis	hemionitis			2	8	10			Spn,Canrys	92/45
399	Polypodium	scouleri		leather polypody	20	7	14	TNJ	Wash	N.Am	94/10 93/97
400	Polypodium 1	amorphum		irregular polypod	20	7	8	R	Oreg.ColumRvr	Pacific NW	94/97
401	Polypodium 2 3	vulgare	Bifido-cristatum	common polypody	1	4	14	NTJK		Cosmo	94/45
402	Polypodium 2 4	cambricum	semilatum	welsh polypody	2	3	8	TN		sw Calif	94/9,154
403	Polystichopsis	mutica			5	8				Jap	94/45
404	Polystichum 2	Munitum	Twisted Pinna	Sword Fern	20	5	36	SNK		W.N.Am	94/25
405	Polystichum 2 3	setiferum	Conspiculobum	Soft Shield Fern	3	6	40	TN		Europe	94/45
406	Polystichum 2 3	setiferum	Conspicupinnulum	Soft Shield Fern	3	6	40	TN		Europe	94/45
407	Polystichum 2 3	setiferum	divisilobum angustatum	Soft Shield Fern	3	6	40	TN		Europe	94/45
408	Polystichum 2 3	setiferum	divisilobum cristatum	Soft Shield Fern	3	6	40	TN		Europe	94/97
409	Polystichum 2 3	setiferum	Mrs Hughes	Soft Shield Fern	3	6	40	TN		Europe	94/45
410	Polystichum 2 3	setiferum	Rotundatum	crested Soft Shield Fern	5	6	40	TN		Europe	94/45
411	Thelyptens	dicursive-pinnata			5	8	12			Eur	94/150
412	Thelypteris 1	Dentata		DownyMaiden,BlueStemfm	3	6	20	AHTKN		Pantrop	94/156 93/1
413	Woodsia	ilvensis		Rusty Woodsia	13	4	6	ERTNZ	Bohem	EasiaNAmEur	94/12,45,150,12
414	Woodsia	plummerae		plummers cliff fern	8	7	14	RNT		MexSW US	94/97

DN#	FIRST	LAST
1	Brian	Aikins*
3	Wayne	Baxter
4	Wendy	Born*
5	Mrs Alice J.	Burkman
6	Anna Maria V	Davis
7	Sylvia & Phil	Duryee
8	Leslie	Duthie
9	Patrick	Dwyer*
10	Sue& Herman	Entz
11	Iris	Gaddis*
12	Wolfram	Gassner*
13	Chris	Goudy
14	Eldred	Green
15	Greg	Haines
16	Neil	Hall
17	Marguerite	Hankerson
18	Kenneth	Hanover*
18	Ken	Hanover
19	Leslie	Hatfield
20	Jocelyn	Horder*
21	JR	Horrocks
22	Barbara Joe	Hoshizaki
23	Guy	Huntley
24	Clive	Jermy. Hon
25	Judith	Jones*
26	Harold Dr.	Kasper
27	Dr. Irving	Knobloch
28	Mareen	Krukeberg
29	Robert W.	Lake
30	Donald	Leake
31	Stuart	Lindsay
32	Lynn	Makela
33	John & Margo	Mascitelli
34	Dr John	Mickel
35	Mary	Muller
36	Sue	Olsen*
37	Barbara S.	Parris
38	Karola M.	Pettkus
39	Ken	Pfeiffer
40	John & Grace	Putnam
41	Martin	Rickard

DN#	FIRST	LAST
42	Jim	Rugh
43	Prof.	Saiki
44	Kevin W.	Sanfers
45	PhDr Zdenek	Seibert*
48	John & Irma	Sjo
49	William	Thomson
50	Fred &	Timm
52	Samuel	Turney
53	Dr. T.W.	Turney
54	Dr. Cor	Van de Moesdijk
55	Mrs. Sandra	Vandermast
56	Suzette	Visentin
57	Les	Vulcz
58	Bruce	Wakeman
59	Elmo	Weeks
60	Reginald	Keye
62	John	Adkins
63	Don	Agostinelli
64	Diane & Ken	Atterbury
65	Roger	Boyles
66	Dorothy	Byer
67	Edmund	Cava
68	Eileen	Clause
69	Michael	Concannon
70	Lothar	Derikewitz
71	Don & Joyce	Drife
72	Joachim	Ehlers
73	John	Game
74	Robert	Gamlin
75	Johan	Kluge
76	Jean	Graber
77	Laura	Gustin
78	Edward	Hallman
80	David	Hughes
81	Yoshio	Kato
82	Shuzo	Kawabata
83	John	Knouse
84	Halyna Mrss	Kuheana
85	Dorothy	Lamb
87	John & Judy	Marley*
88	Hiroki	Miyazaki

DN#	FIRST	LAST
89	Pamelaq	Moscetti
90	Craig	Sauls
91	Dr. Elizabeth	Sheffield
93	Frank Mrs	Skula
94	Val	Sonter
95	Dr. David	Straney
96	Judith	Sullivan
97	John	Thompson
98	Christian	Wingard
99	Dr Bruce	Young
100	Marge	Baird
101	Margaret	Nimmo-Smith
102	E. MD	Hirsch
103	Richard	Piller
104	Prof. Berthet	Lyon Bot. Gdn.*
105	Bryan J.	Laughland
106	Barry	White*
107	Beverly	Edney
108	Catherine	Guiles
109	Phyllis P.	Bates
110	Linda and	Halley San Diego
110	Bob	Halley*
111		HFF
112		AFS/NYBG
113	Naud	Burnett
114	J. C	Punter
115	Gretchen	Gould
116	Rufina	Osorio
117	JOan	Feely
117	Dr. Donald	Farrar
118	Chanin	Thorut
119	Elva C.	Link
120	Dr Alf	Birkrem
122	Mrs Hiroko	Sasashi
123	Betsy	Feuerstein
124	Michael	Garrett
125		HFF Lakewold
126	Jason	Ney
127	Ted	Evers
128	James A.	Rollins
129	MICHAEL	HEIM

DN#	FIRST	LAST
130	Vera	Barton
130	Loyd	Barton
131	Robert	Muller
134	Sandra	Constantino
135	Wim	Tavernier
136	D.J.	Batten
138	Cynthia	Farden
139	Jack	Schieber
140	Alan	Smith
141	Virginia	Otto *
142	Jesse	Perry
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